Risk Based Insight –
Optimizing Performance with Limited Budgets and High Expectations

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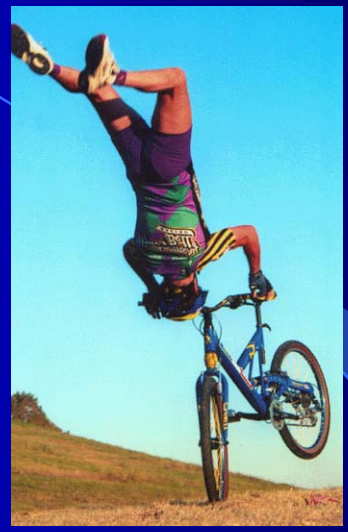
Topics

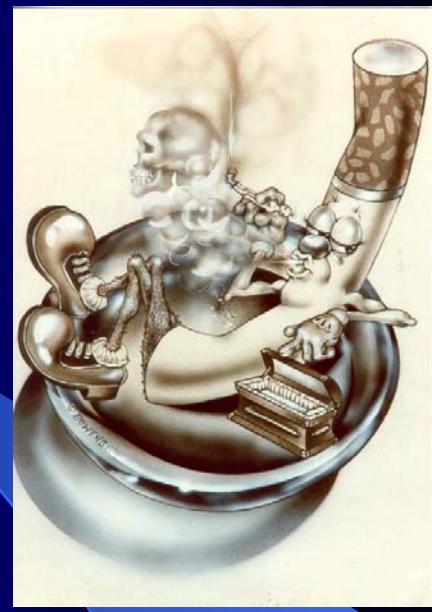
- Can Risk be Avoided?
- The Insight Spectrum
- Using Risk Posture to Determine Project Insight Approach
- Targeted Risk-Based Insight
- Managing Schedule Risk
- Formalizing the Process
- Summary/Conclusion

Can Risk Be Avoided?

Can Risk be Avoided?

- Everything we do involves some risk…





- Exploration and discovery carries high potential return… but also high risk…

What about NASA's Mission?

- **The Mission is not Optional**
  - **"This cause of exploration and discovery is not an option we choose; it is a desire written in the human heart".** *George W. Bush,Johnson Space Center, 2003*

- **Risk is inherent to the Mission**
  - **"We choose to go to the moon! We choose to go to the moon, by the end of this decade and do the other things, not because they are easy, but <u>because they are hard</u>!"** *John F. Kennedy, Rice University, 1962*

…Therefore, we cannot avoid risk!

So….We Deal with it

- We can never mitigate <u>all</u> risk, so we must manage it…
  - We mitigate what we can, but *we will accept some residual risk*
- As a NASA community, we need to accept and embrace this reality
  - "It is unlikely that launching a space vehicle will ever be as routine an undertaking as commercial air travel – certainly not in the lifetime of anybody who reads this. The scientists and engineers continually work on better ways, but <u>if we want to continue going into outer space, we must continue to accept the risks</u>." *– CAIB Report, Part I, Page 9.*
- We "manage risk" through:
  - Proactive understanding
  - Calculated assessment
  - Focused mitigation

- As practitioners, we need to improve the way we facilitate the process

The Insight Spectrum

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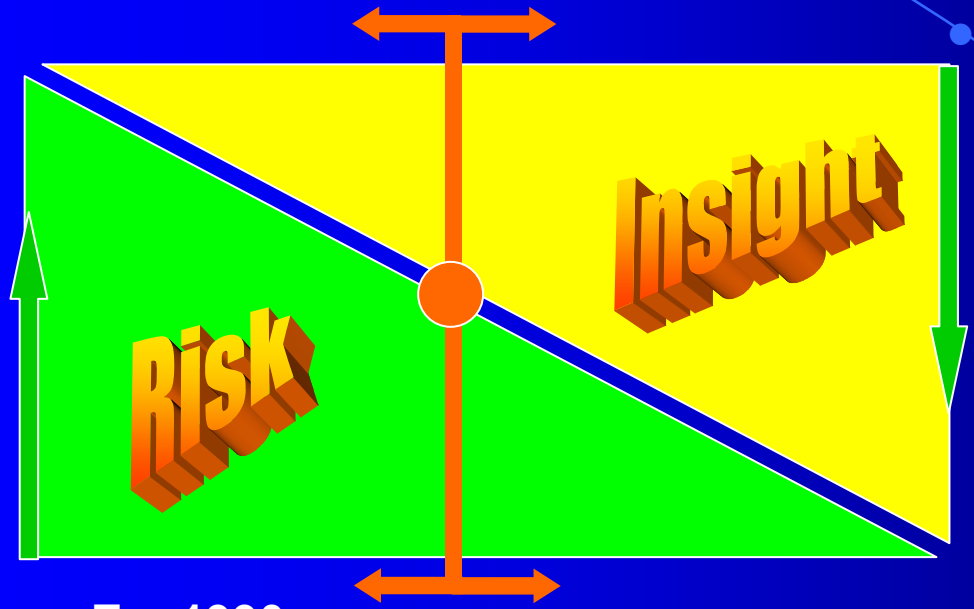
The Historical Insight Spectrum



- Ex: Apollo era
  - Hefty budgets
  - Complete government oversight & insight into hardware development and integration
    - Most work performed by either civil servants or in-house contractors
    - Signature approval authority of all significant technical work
- Ex: 1990s
  - Severely constrained budgets
  - Prevalence of "Faster-better-cheaper" mentality
    - Autonomous contractor development
    - Government insight limited to regular status briefings

The Insight Spectrum

Oversight (Control) — Insight (Trust)

Apollo Shuttle Hubble Chandra X-33, 34 GP-B PI-Class Payloads

- Specification Control
- Approval of Level III Changes
- NASA Design Certification
- Verification Approval
- Duplication of Analysis
- Large NASA Team

- Approval of Level II Changes
- Thoroughly Review Test Planning
- Review Test Procedures
- MRB Membership
- Approval of Verification Items
- Observe All Major Tests; Analyze Data
- NASA Certification of Verification
- Fault Tree Evaluations & Special Studies
- Medium NASA Team

- Approval of Level II Changes
- Contractor Design Self-Certification
- Review of Analysis
- Approval of Verification Plans
- Small NASA Team

The Insight Spectrum

- Miscalculations of "Faster, better, cheaper"
  - You can simultaneously speed the work, increase the quality, and reduce the cost.
    - These are opposing project management parameters
    - Constraining all three parameters is reckless and presents a recipe for failure
  - The public and Congress will tolerate failure
    - This did not turn out to be the case
- But, for the foreseeable future, NASA's budgets will be limited

…so what do we do?

- We optimize efforts through focused insight based on the project risk.
  - Overall Program risk posture determines insight approach and activities
  - Individual program risks determine focused insight efforts

Using Risk Posture to Determine Project Insight Approach

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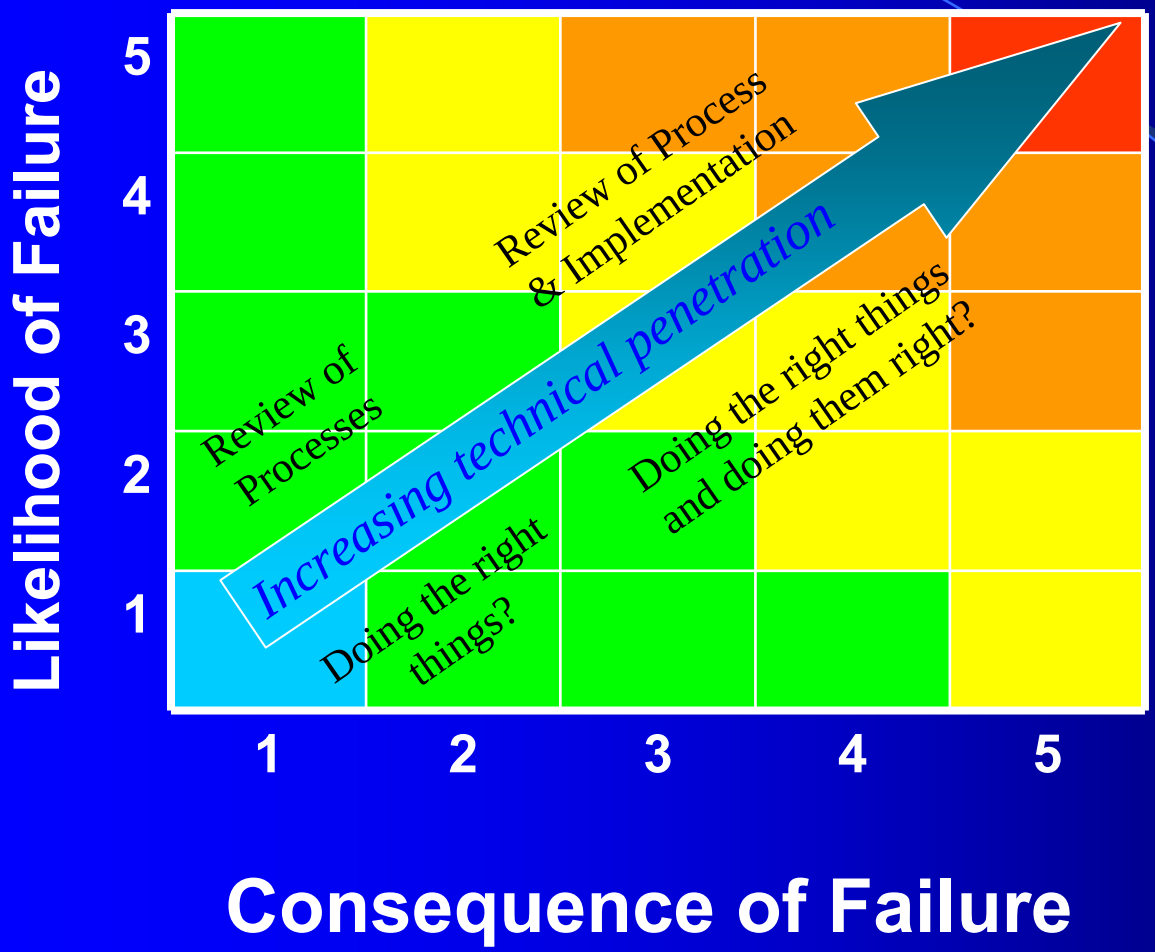
Determining Appropriate Insight-Level

- Develop project risk assessment early in the project life cycle *(Phase A/B)*
  - Utilize 5X5 (likelihood X consequence) approach
    - Universal benchmark for NASA projects
    - ERASMUS requirement
- Develop insight posture based on calculated risk
  - Low risk
    - Review processes
    - Doing the right things?
  - Higher risk
    - Review processes and implementation
    - Doing things right?
    - independent validation

Risk Posture → Insight Level



- Level of Penetration in proportion to Program Risk Posture
- Normally assessed at beginning of Program to establish:
  - Insight/oversight role
  - Depth of penetration

Project Planning for Insight

- Build Project Plan around risk posture
- Include appropriate NASA Resource loading
  - Technical/Engineering teams
  - Project support teams
- Statement of Work and Contract deliverables
  - SOW language
    - High risk – more controlling/explicit language
    - Low risk – more authority/freedoms to the contractor
  - Deliverables
    - High risk – more Type I/II, deliverables
  - Standards
    - High risk – Standards as requirements, formal meet/exceeds reviews
    - Low Risk – Standards as guidelines
- Program and Design Review plans and structures
  - High risk – Formal SRR/PDR/CDR/DCR/FCA/PCA/ARB/FRR
  - Low risk – Technical Interchange meetings, monthly reviews

Depth of Penetration – Based on Risk

Risk Level	Penetration Tasks	Out-of-sight	Insight
0 No Penetration	• Accept contractors tasks at face value (based on assessment that no penetration required)	Y	N
	• Contractor develops and implements verification plans	Y	N
1 Low Penetration	• Participate in reviews & Technical Interchange Meetings, assess only data presented	Y	N
	• Chair board or serve as board member or RID writer, at a formal review	Y	Y
	• Perform periodic audits on pre-defined process(es)	Y	Y
	• Participate in resolution and closure of issues	Y	Y
	• Review verification plans and its implementation	N	Y
2 Intermediate Penetration	• Low penetration w/ addition of daily/weekly involvement to identify & resolve issues	N	Y
	• Review verification plan, its implementation, and selected verification closure data	N	Y *
3 In-depth Penetration	• Intermediate penetration with addition of:		
	1) Methodical review of details (review ADPs, VLOAs, etc.)	N	Y
	2) Independent models to check and compare vendor data, as required	N	Y
	• Review verification plan, implementation, and concur in all verification closure data	N	Y*
4 Total Penetration	• Independent review of all verification documentation (including closure data) and witness verification testing	N	Y**
	• Perform a complete and independent evaluation of each task	N	N
	Estimated Penetration Level	**~ 0.8**	**~ 3.2**

* Level I, II, and III + Mission Ops requirements

** Limited test witnessing

Targeted Risk-Based Insight

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Targeted Risk-Based Insight

The real world means…

- Funding limitations often limit insight capability
- Overall insight levels may not be commensurate with Program risk posture
- Knee-jerk reaction to failure/mishap demands more insight, but without additional funding

… so how do we respond?

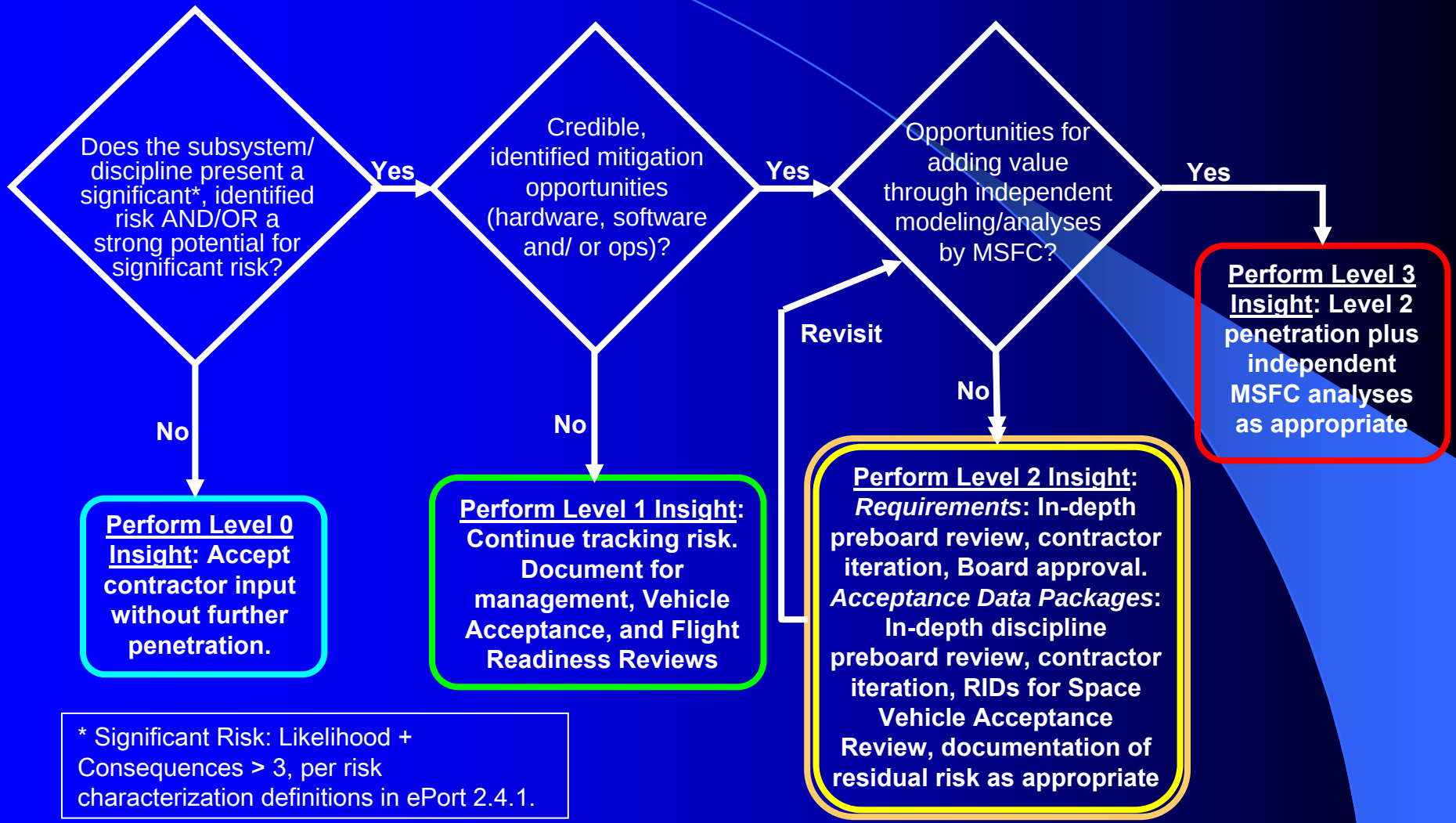
- Optimize further… target insight toward significant risk
  - Lack of flight heritage
  - Limited testing
  - Irregularities with procurement, parts selection, documentation
  - Quality Assurance concerns
- Determine if opportunity for mitigation exists
- If not, codify process for formal "acceptance"

Target Risk Items for Mitigation

Issue/concern	Associated program risk	1. System test on fully integrated vehicle to include powered electronics	2. Testing & inspection	3. Long-duration software test	4. ED concurrence on TRR, DR, and AR closure	5. Delta ADRs with ED concurrence	6. Unlimited access for Marshall site reps	7. Verify EEE parts qualification	8. Complete structural analyses of flight systems	9. Complete structural analyses of ground systems	10. Retest vatterfly valves for leakage	11. ED concurrence on purity of delivered He gas	12. Require rationale for materials performance in long-term cryogenic environment	13. Develop integrated plan for vatterfly valve and filter requirements	14. Add vehicle-level EMI test	15. Improve engineering management	16. Develop system-level FMECA/FTAs	Program risk after mitigation
1. Phasing of insight involvement by MSFC/ED	H	H	-	H	M	H	M	H	-	-	-	-	L	-	-	-	H	M
2. Interaction with contractor	H	H	-	H	H	H	H	L	-	-	-	-		-	-	H	-	L
3. Requirements traceability	H	H	-	M	M	H	M	M	-	-	-	H	M	-	-	M	H	M
4. Process control	H	H	H	H	H	H	H	M	-	-	-	H	-	-	-	H	H	M
5. Lack of post-integration cable testing	M	L	M	L	-	-	-	-	-	-	-	-	-	-	-	-	-	L
6. Insufficient analysis of failures	H	H	H	H	H	H	H	M	-	-	M	-	-	M	-	M	H	M
7. Verification of EEE parts	H	M	L	L	M	M	-	H	-	-	-	-	-	-	M	L	M	M
8. Gyro caging failure	M	-	-	-	-	L	-	-	-	-	-	-	-	-	-	M	H	M
9. Structural analyses unavailable	H	-	-	-	M	L	-	-	H	H	-	-	-	-	-	L	-	L
10. Impurities in cryo lines	H	-	-	-	-	-	-	-	-	-	-	M	L	-	-	M	H	M
11. Unverified vatterfly valve flight configuration	H	-	-	-	M	M	-	-	-	-	H	-	-	H	-	M	M	L
12. Gas purity concern	H	-	-	-	M	-	-	-	-	-	-	H	-	-	-	H	M	L
13. Contamination from vatterfly valve filters	M	-	-	-	M	-	-	-	-	-	-	-	-	H	-	M	M	L
14. Materials stability in cryogenic environment	M	-	-	-	-	-	-	-	-	-	-	-	H	-	-	-	M	M
15. Engineering management	H	-	-	-	M	M	H	M	-	-	-	-	-	M	-	H	M	M
16. EMI testing	H	-	-	-	M	-	H	M	-	-	-	-	-	-	H	-	-	L
17. GMA Risk Mitigation Plan	M	H	-	M	H	L	H	-	M	-	-	-	-	-	-	-	M	L
18. Schedule concerns may threaten	H	H	-	-	H	-	H	L	-	-	-	-	-	-	-	-	-	M
Implemented?		Y	P	Y	P	P	Y	TBD	Y	Y	P	Y	TBD	P	P	P	P	

Key													
	Risk level							Mitigation value					
	High:	H	Medium	M	Low:	L		High:	H	Medium	M	Low:	L
	Implementation level												
	Yes:	Y	No:	N	Partial:	P							

Targeted Risk-Based Insight



* Significant Risk: Likelihood + Consequences > 3, per risk characterization definitions in ePort 2.4.1.

Penetration Examples

	Verification		Acceptance	
Level	Activity	Example	Activity	Example
0	No penetration; accept contractor certification; no signature	None	No penetration; accept contractor certification; no signature	Ballast
1	Low-level penetration; discipline team documents evaluation and any risk; no Board signature	1.a.3.1; Electrode thickness	Low-level penetration; discipline team evaluates for risks & documents any found; no RIDs	Science gyros
2	Intermediate penetration; review data & request additional as required; Board signature	3.5.3.4.2; Drift phase of calibration signal	Intermediate penetration; review data & request additional as required for closure; RIDs as required	Payload electronics
3	In-depth penetration; data review includes independent analysis, as required; Board signature	24.2; Semi-major axis	In-depth penetration; data review includes independent analysis, as required for closure; RIDs as required	Dewar (thermal model)

Managing Schedule Risk

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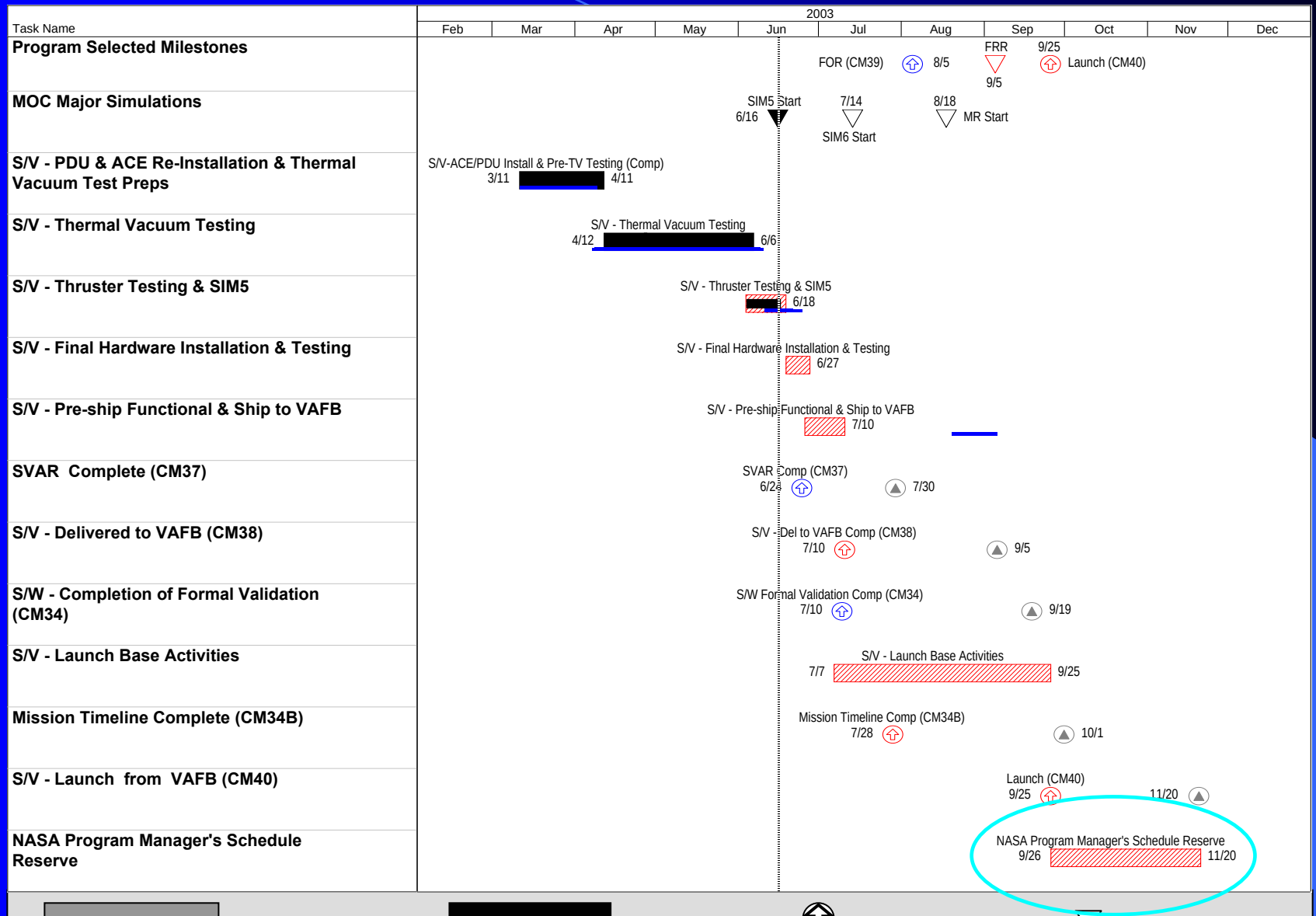
Managing Schedule Risk

- Schedule risk is just as important as technical risk – Slip too much and you risk cancellation
- Schedule risk must also be “managed”
- Schedule risk (liens and threats) should be determined and tracked
- A disciplined process/system adds credibility to the assessment
- This section shows a possible implementation of schedule risk management

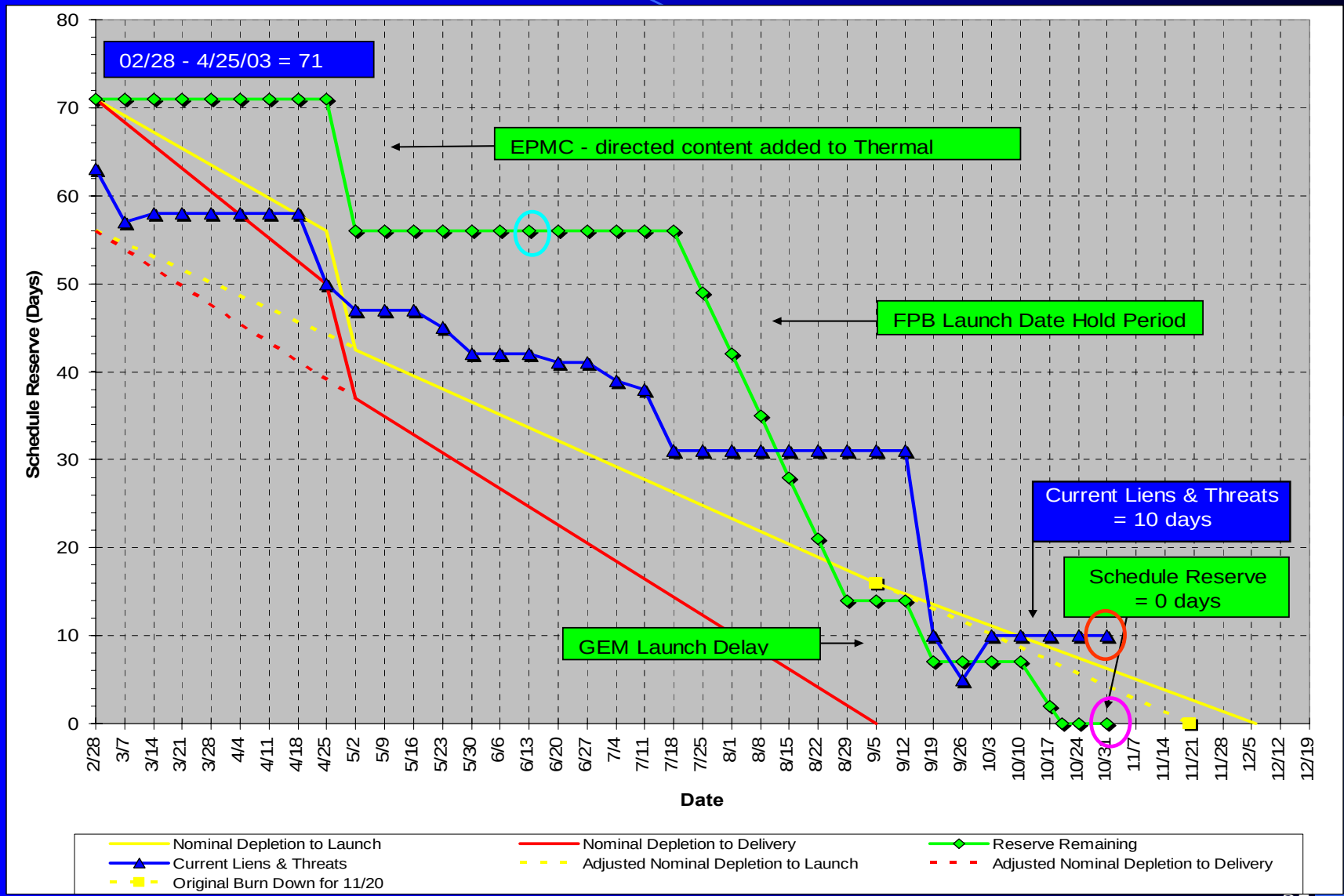
Schedule Lien & Threat Process

- Generate a list of all potential Liens and threats
  - Lien: An activity not included in the schedule. Its inclusion is required, but the baseline change has not been approved by the CCBD.
  - Threat: An activity that will be included in the schedule if certain events occur and can impact the critical path
- Characterize/Define Liens & Threats
  - Assign an estimated duration in terms of critical path impact if realized
  - For threats, assign a probability of occurrence
  - Add 'em up – use this to develop reserve posture for Program Commitment Agreements and Replans
- Regularly review critical path with contractor – track actuals versus plan
- Regularly report status to stakeholders/customers

Master Schedule – as of 6/03



Liens / Threats – As realized

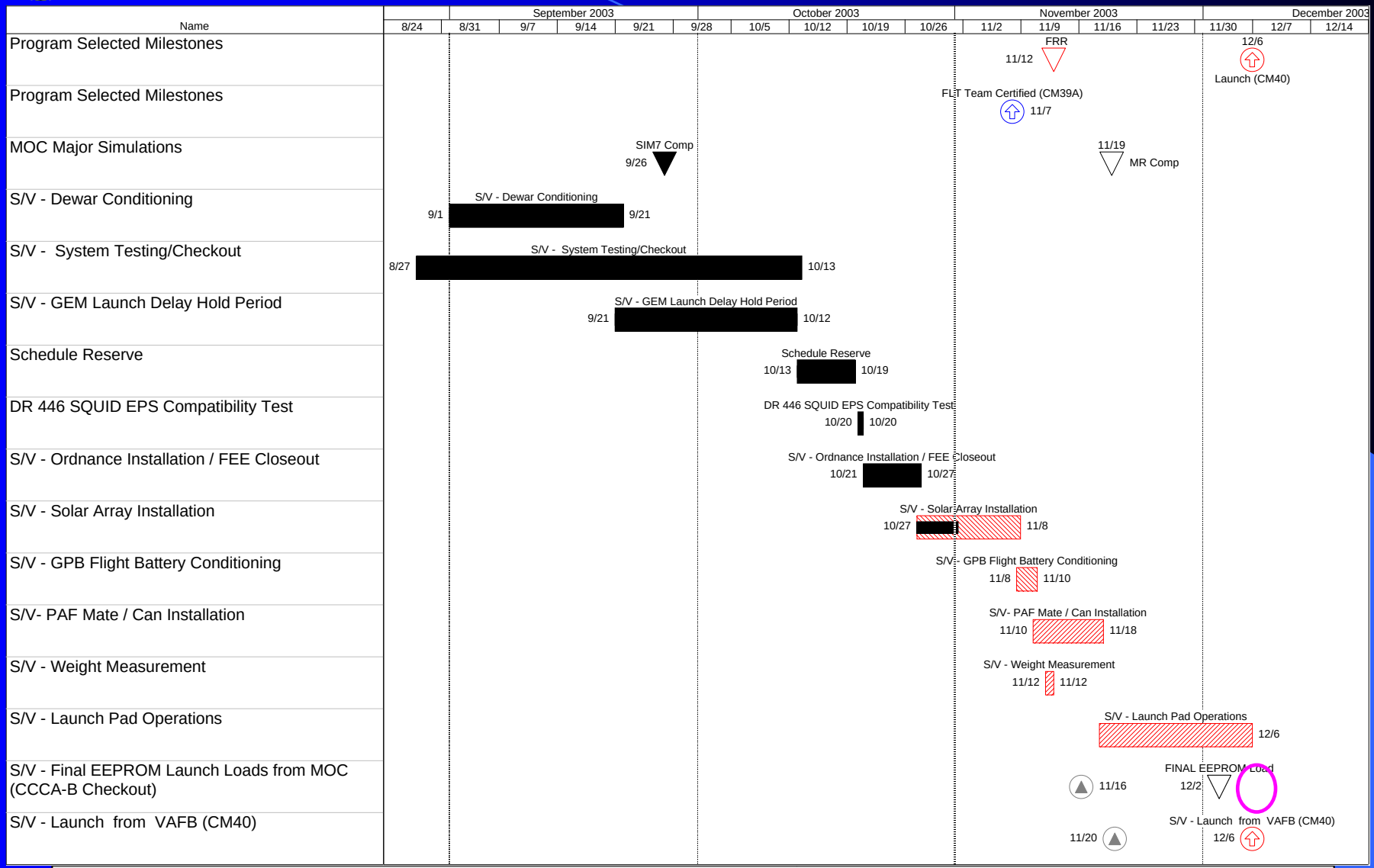


Liens & Threats Status – As realized

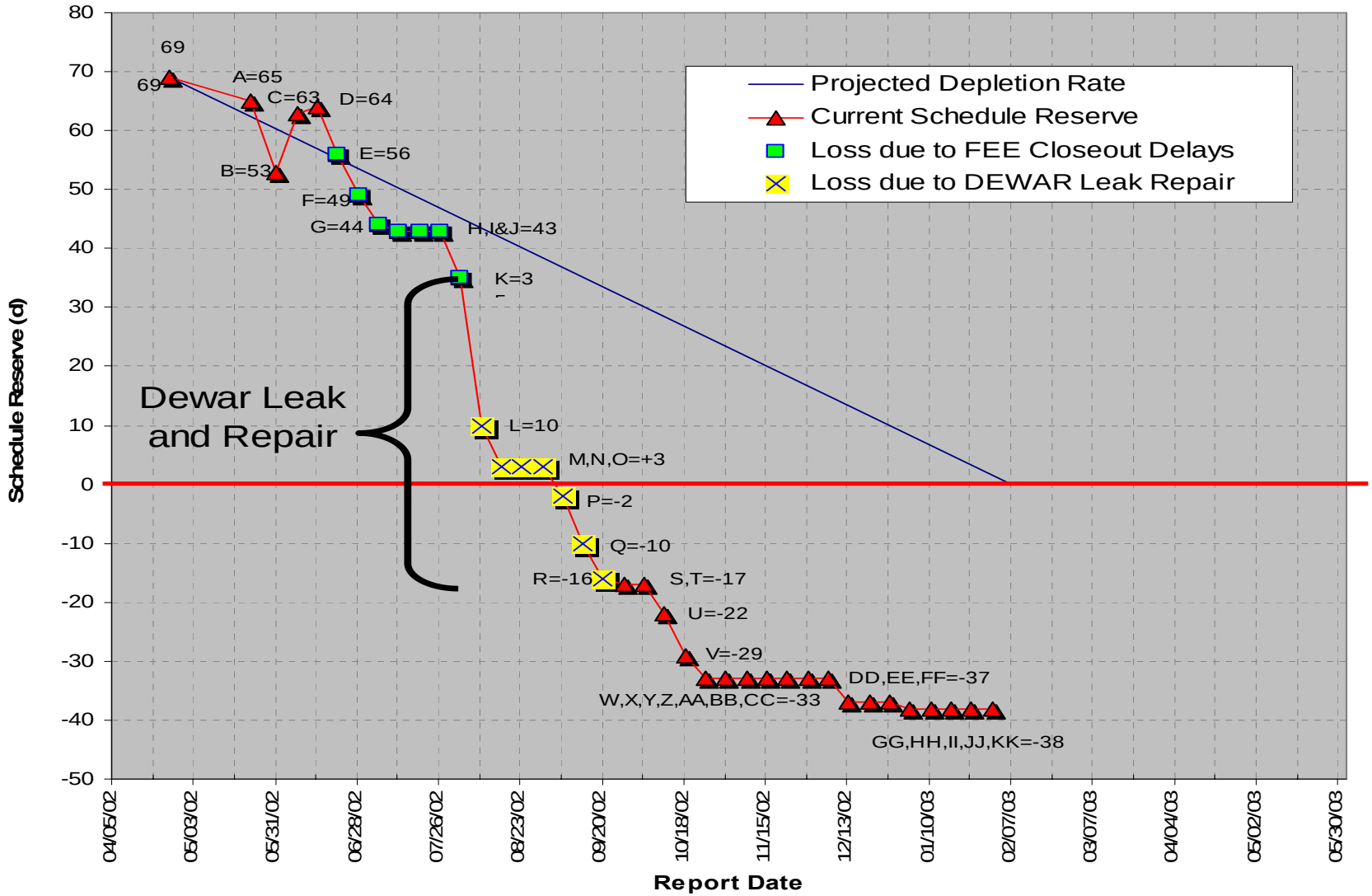
Title	Expected Lien	Threat	Realization Factor (%)	Expected Threat	Comment/Status	Realized Actual	Retired
~~Working Off Existing Discrepancy Reports~~	0			0	~~Large number of small repairs~~		2
~~Software FQT Delays~~	0			0	~~Retest Threat~~		4
~~Thermal Vacuum testing of PDU after repair~~	0			0	~~No T/V Testing - Only Thermal Cycle~~		9
~~Star Tracker Rework~~	0			0			1
~~E-28 completion~~	0			0	~~2 minor tests remain~~		2
~~Guard Tank Hold Time Analysis Testing~~	0			0	~~Quantify GT refill cycle at VAFB~~		3
~~EMI Testing~~	0			0	~~Added Test Rqmts - SU PCB Rec~~		3
~~Delays during Thermal Vac Prep/Execution~~	0			0	~~Previous problem (MLI) now resolved~~		2
Dewar Leak/Repair	0	18	10	2	Fill ops exacerbate/Retire at Launch		0
~~Tilt Ring use for GUPPY Pathfinder Operations~~	0			0	~~Use may take longer than planned~~		1
~~Transport Delays to VAFB (Wx or CalTRan)~~	0			0	~~Wx or CalTran delaying transport~~		1
~~CTV Testing for replaced transponder~~	0			0	~~Work in parrallel w/ no CP impact~~		3
~~GMA Ops at pad, 5 to 4 day Guard Tank fill~~	0			0	~~Work in parrallel w/ no CP impact~~		2
Final Flight Software Validation @ VAFB	0	3	25	1	Will retire after final launch load		0
RIFCA Corona	0	20	10	2	Expect addnl testing to exhonerate		0
SRE Bus Voltage Ripple	0	5	20	1	Troubleshooting I/W		0
Unknown Unknowns	0			0	Historical delays fall in this categ.	15	5
Pre-dewar Conditioning Hold	0			0	Burn down of hold period (5 d/wk)	22	0
Totals					**Grand Totals**		
Work Days	**0**			**6**	**6**	**37**	**38**
Calendar Days	**0**			**10**	**10**	**53**	**54**

Current Master Schedule

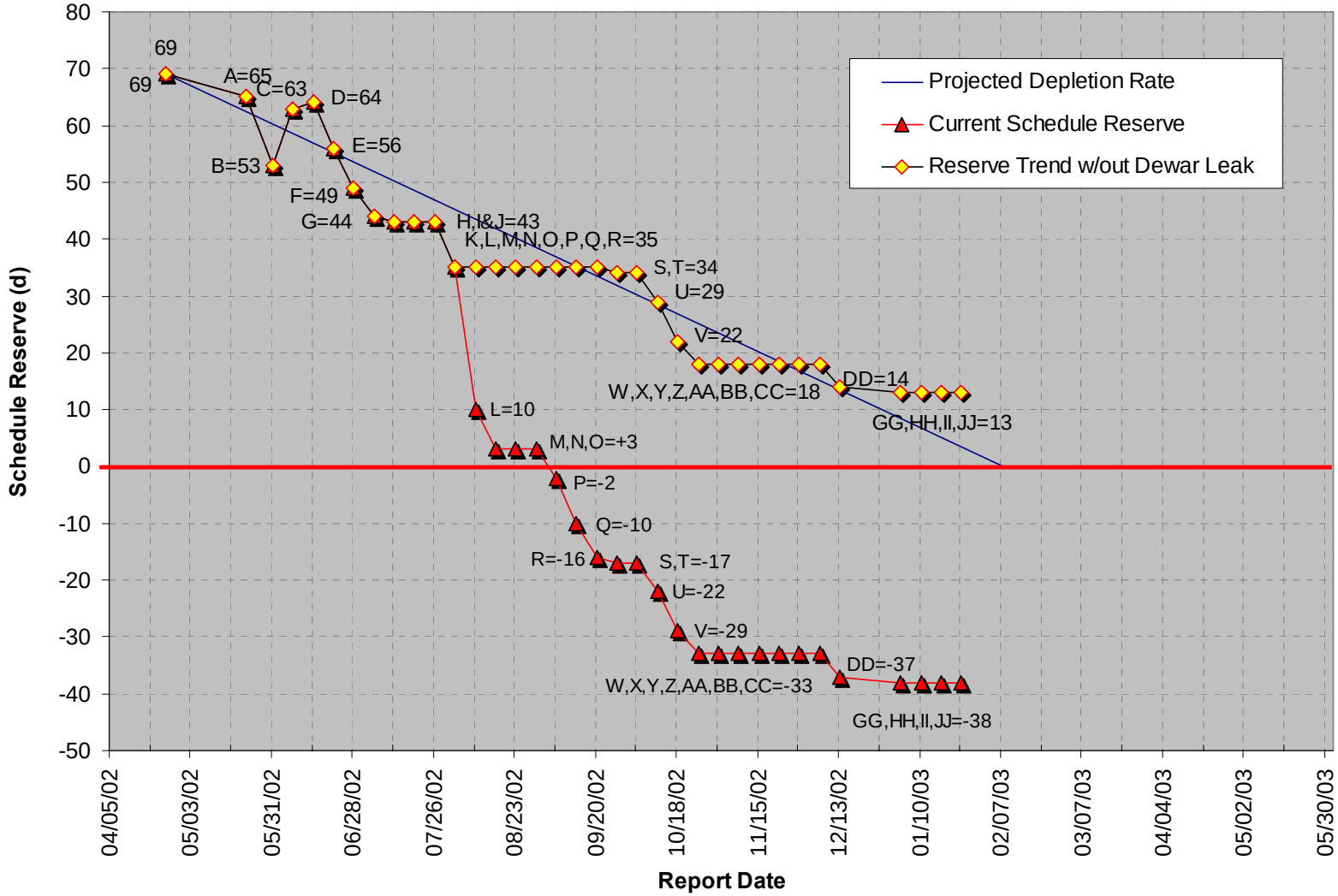
(as of 10/31/03)



Reserve Depletion – Tells the Story

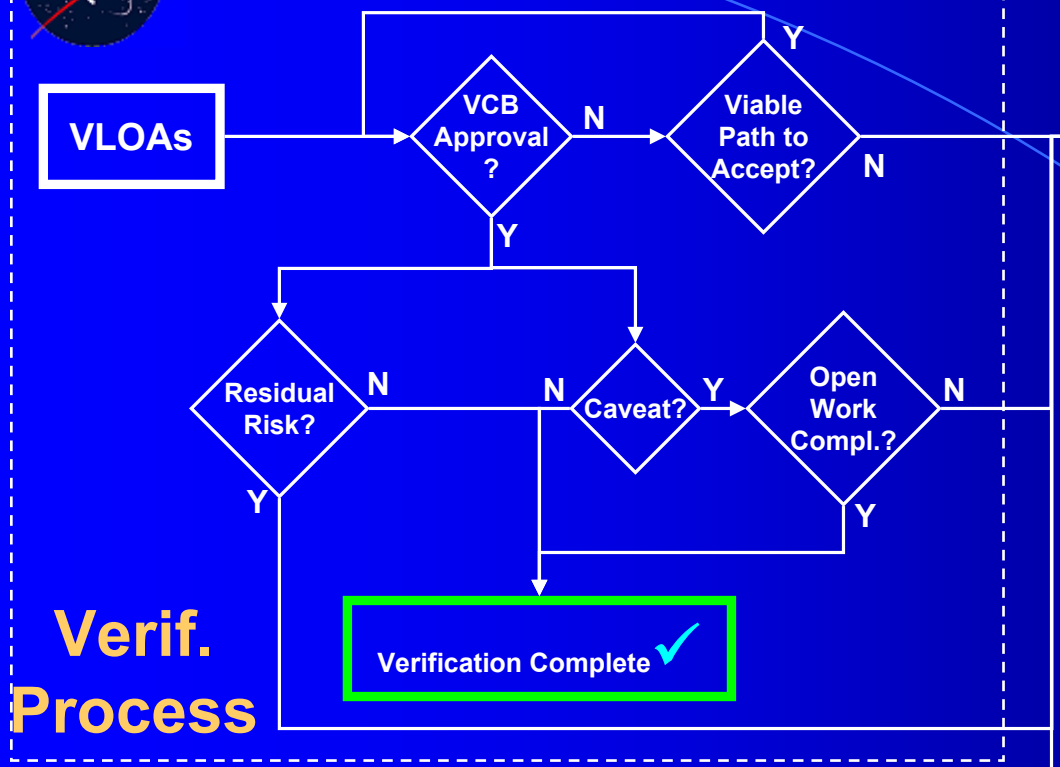


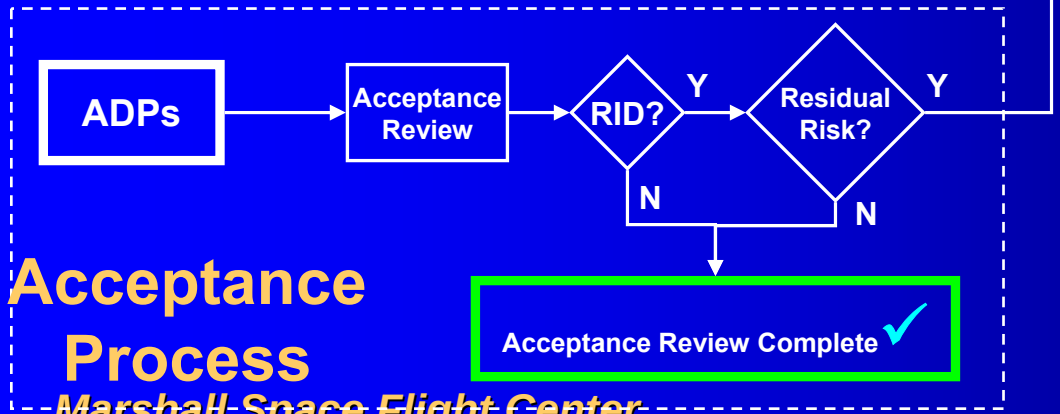
Reserve Depletion – Tells the Story II

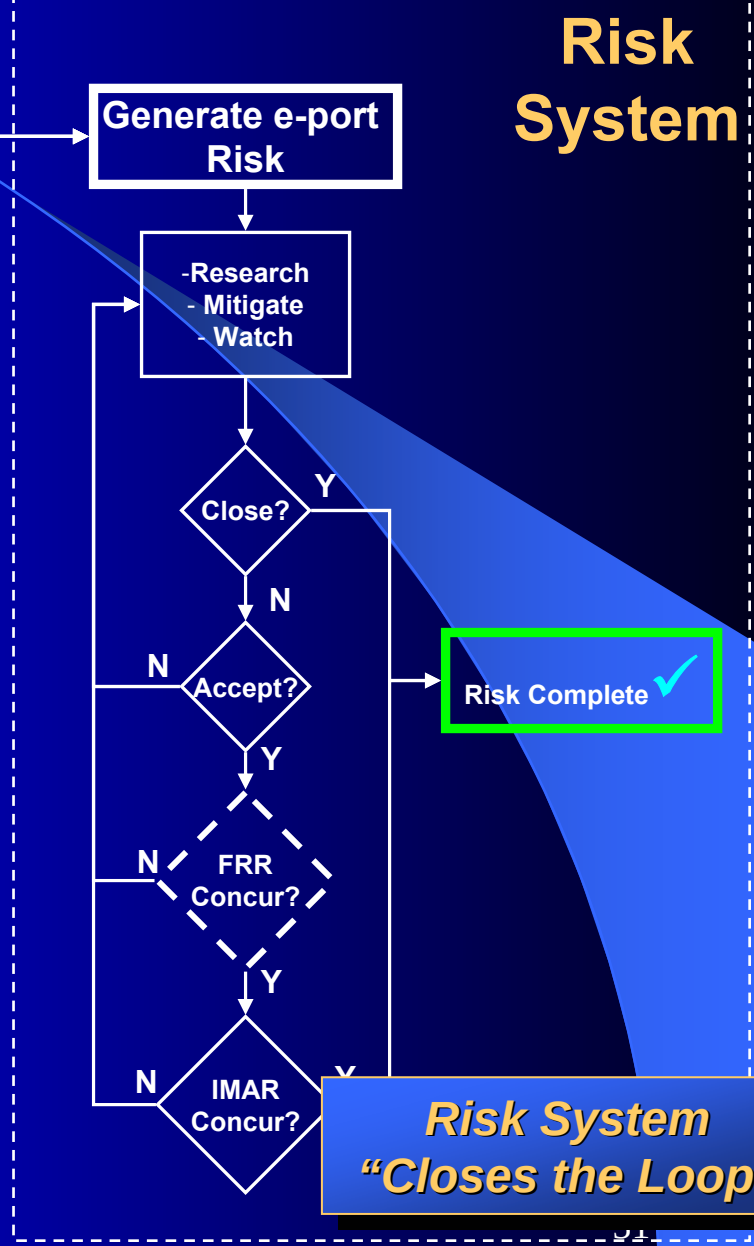


Formalizing the Process

Codify the Risk Acceptance Process







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5X5 Criteria and Approach

	Likelihood	Consequence		
	All Types	Cost	Schedule	Technical
RISK VALUE	Chance of Occurrence	Given the event occurs, what is the magnitude of the impact to the Program?		
5	Near certainty: 90% Chance	Program cost increase: > $8 M	Critical Path impact: > 60 days	Loss of mission.
4	Highly likely: 75% Chance	Program cost increase: >$4M but ≤8M	Critical Path impact: 31 - 60 days	Mission performance requirements degraded.
3	Moderate: 50% Chance	Program cost increase: >$1M but ≤4M	Critical Path impact: 8 – 30 days	Loss of some system level redundancy; no compromise of mission requirements
2	Low likelihood: 25% Chance	Program cost increase: >$100K but ≤1M	Critical Path impact: 1 – 7 days	Technical impact without loss of system level performance or redundancy.
1	Not likely: 10% Chance	Program cost increase: ≤ $100K	Critical Path impact: None	No compromise in mission performance or redundancy.

5X5 Criteria

Mitigate: Eliminate or reduce the risk by reducing the impact, reducing the probability or shifting the timeframe.
Research: Investigate the risk until you know enough to be able to decide who is responsible for the risk and what approach to take (i.e., mitigate, watch or accept).
Watch: Monitor the risks and their attributes for early warning of critical changes in impact, probability, timeframe, or other aspects.
Accept: Do nothing. The risk will be handled as a problem if it occurs. No further resources are expended managing the risk.

Approach

Example Risk

Version 5 submitted on 11/6/2003 12:10:00PM

Group Access: Everyone

M

Risk Total Score: 12

Risk Information Sheet

Planned Closure Date: 12/06/03

Likelihood 3

Consequences

Cost 1

Schedule 1

Technical 4

Risk Title

Unverified ACE Box-Level Requirements

Risk Statement

Description: ACE box-level requirements not verified because VRCD not provided with ADP. Acceptance procedures provided contain numerous steps that have been redlined out.

Impact: Potential for ACE box not to perform required functions.

Team
Avionics

Owner
Bill F

Category
-

Timeframe *Near* [X] *Mid* [ ] *Far* [ ]

Context

The ACE specification requires verification of the 250+ requirements for the ACE, but according to LM Representatives, this scope was deleted from the SA subcontract by LM to reduce cost. Without the ACE VRCD the review of the data package submitted by LM could not be completed and thus the verification of most of the ACE requirements was not possible. Many of the requirements in the ACE specification are direct flow down or derived requirements from the Spacecraft Specification, P086811 Rev H, and T003, Mission ( ) System Design and Performance Requirements.

Approach *Research* [ ] *Mitigate* [ ] *Watch* [ ] *Accept* [X]

Research Plan

Review additional data from Request Log item 747.

Mitigation Plan

Request that LM deliver the documentation package that was used to review and accept the ACE from , i.e., LM-to- SOW, acceptance package and acceptance presentation, CDR presentation and documentation package.

Example Risk (cont.)

Detailed Mitigation Plan

No mitigation steps recorded.

Watch Plan/Tracking Requirements

Acceptance Rational

NASA wrote an SVAR RID (#0016) and at least four Request Log Items to obtain the VRCD. These methods did not result in obtaining the required verification data to enable independent NASA validation of verification results. The probability of obtaining data with additional efforts is low. Therefore, the Risk Owner recommends accepting this risk, which also removes it as a constraint to Space Vehicle Acceptance.

Management Comments

The Program Office concurs with the Risk Owner's recommendation to accept this risk.

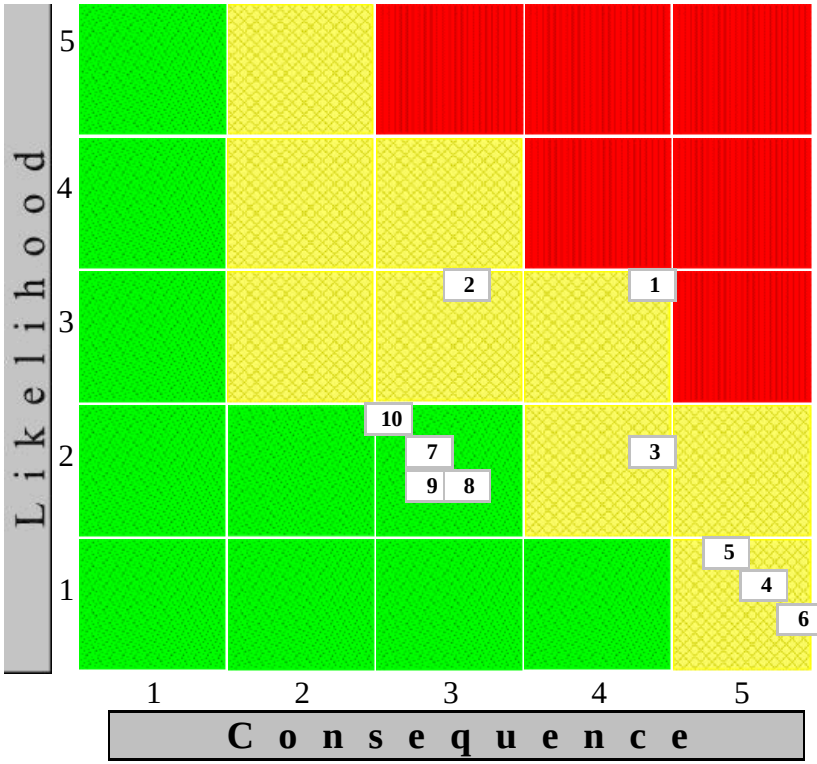
Previous Status Comment

11/06/2003	NASA wrote an SVAR RID (#0016) and at least four Request Log Items to obtain the VRCD. These methods did not result in obtaining the required verification data to enable independent NASA validation of verification results. The probability of obtaining data with additional efforts is low. Therefore, the Risk Owner recommends accepting this risk, which also removes it as a constraint to Space Vehicle Acceptance. PCD changed from 11/6 to 12/6/03. --- 11/04/03 - RL 764, Research associated with Risk GP-B-89, opened 10/28/03 and closed 10/29/03, requested explanation of E7 results with respect to ACE requirements.
10/30/2003	Reviewed E7 spacecraft test data for ACE-specific results. Entered a new Request Log item requesting explanation of E7 results with respect to ACE requirements. PCD changed from 10/30 to 11/06/03.
10/21/2003	Request Log verification data has been provided to to review the data. PCD changed from 10/16/03 to 10/30/03. Approach changed from Mitigate to Research.
10/02/2003	Added statement to Management Comments, that this risk is a constraint to Space Vehicle Acceptance.
10/02/2003	Request Log Items 745 - 747 have been entered to obtain additional verification data.

Systematically Risk Evaluation

5x5 Risk Summary From 11/12/2003 (FRR) to 02/19/2004

(Top 10 Risks)



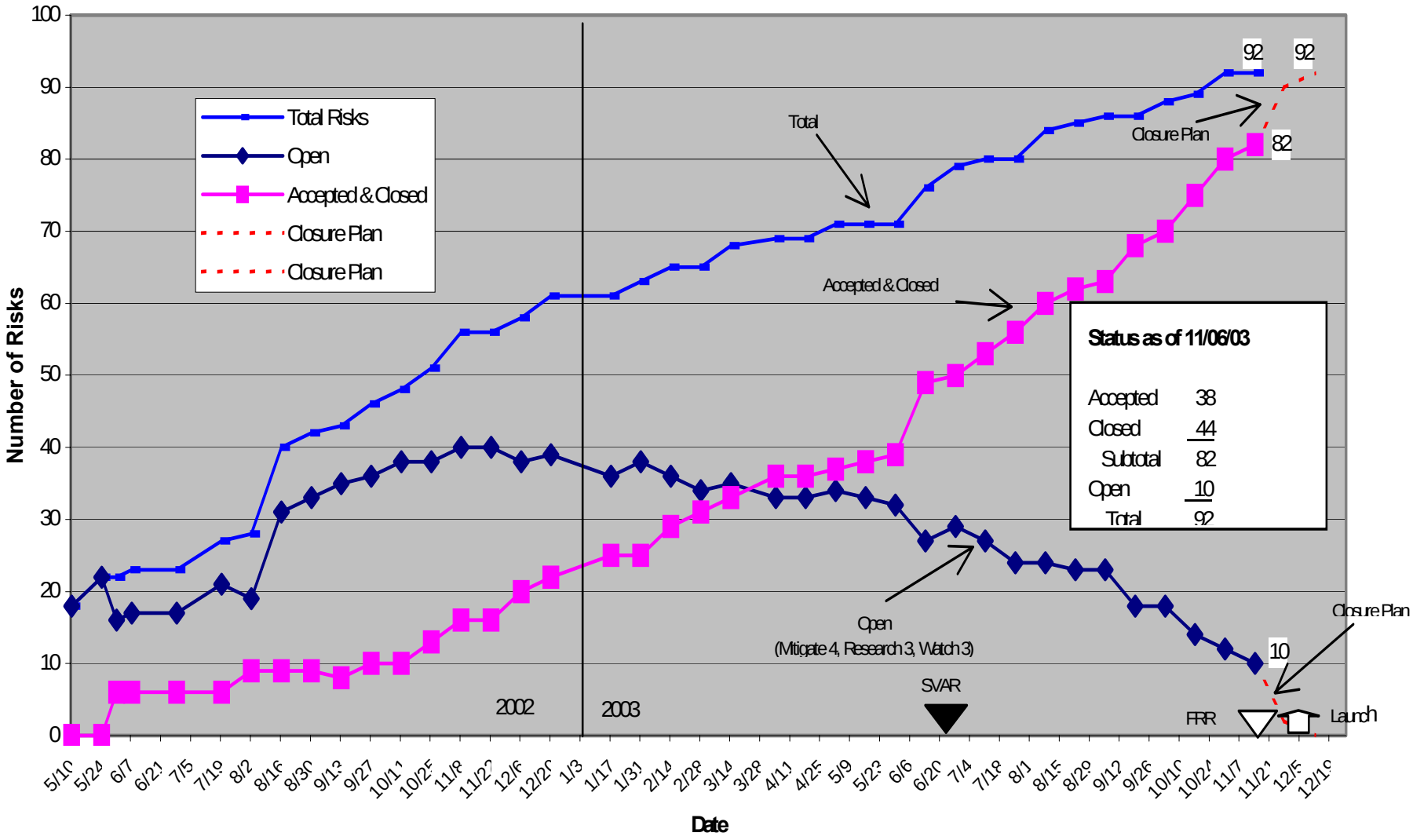
LxC Trend	Rank From	Rank To	Risk ID No.		Approach - Risk Title
Unch	1	1	GP-B-89	A-	Unverified ACE Box-Level Requirements
Unch	2	2	GP-B-55	A-	Loss of F0 Clock Source because of Poor Quality Parts
Unch	3	3	GP-B-87	A-	Unverified Thermal Control System Modifications after System Level Thermal Vacuum Test
NEW	--	4	GP-B-97	M-	Additional Operations with Pyro Devices due to Launch Delay
Unch	6	5	GP-B-90	R-	Flight Sunshade Shutter Actuator Different From the Cycle Tested Actuator
Unch	5	6	GP-B-22	A-	Degraded Mission Performance due to Ground Testing Limitations
Unch	7	7	GP-B-16	A-	Vatterfly Valve Seals Leakage During Launch and Ascent
Unch	8	8	GP-B-39	A-	Impurities in Cryo System
Unch	9	9	GP-B-44	M-	Physical Damage to Solar Arrays During Ground Handling
Unch	10	10	GP-B-15	A-	Failure of Payload Electronics Box(es) During Vehicle Testing

Criticality

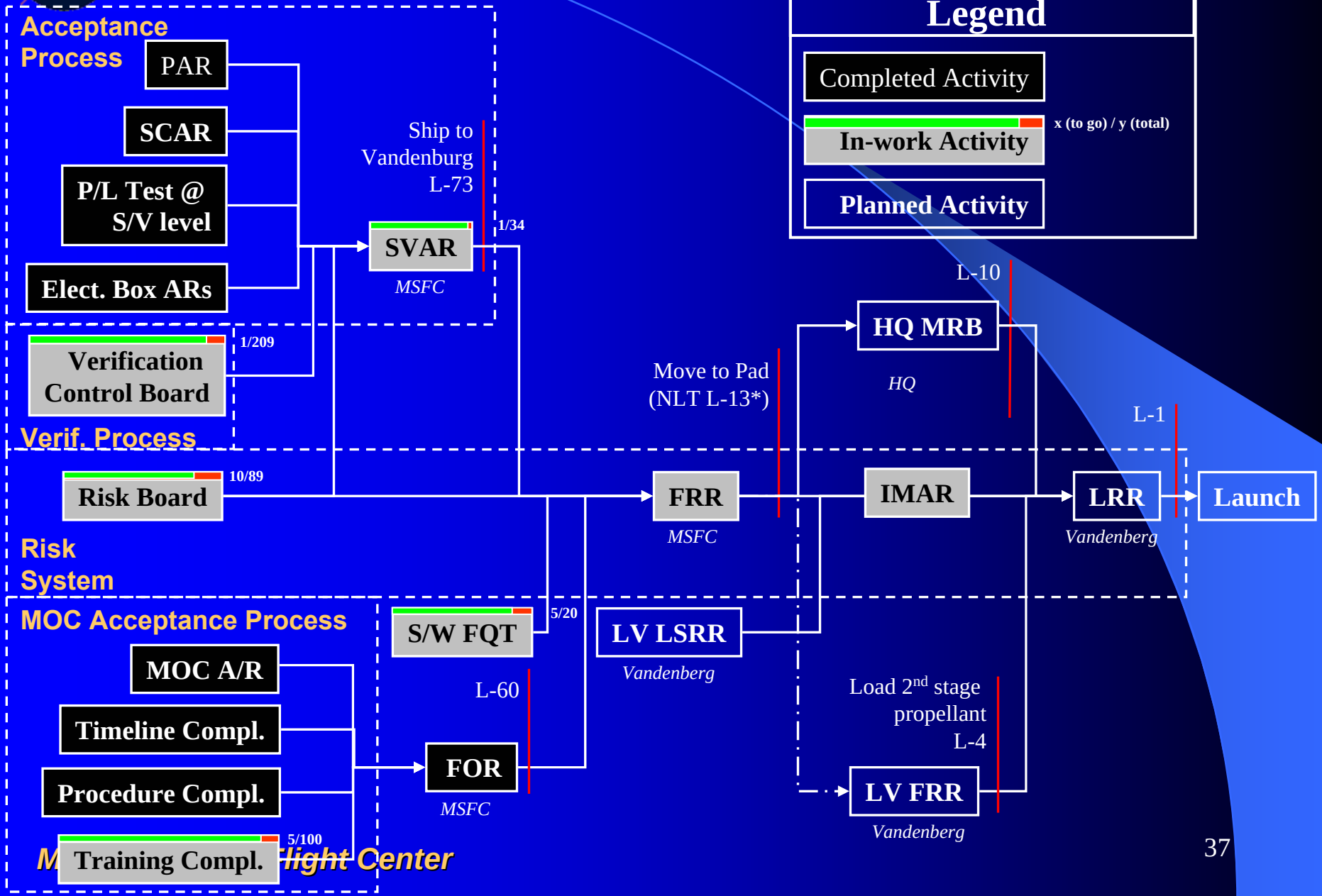
- High
- Med
- Low

	Current Period			30 Days Ago			60 Days Ago			90 Days Ago		
H, M, L	0	6	42	0	7	45	0	7	42	0	8	39
Open	48			52			49			47		
Closed	54			50			50			49		
New	0											

Risk Tracking



Risk System Carries You to Launch



Conclusions

NASA Mission carries inherent risk, but…

….fiscal constraints preclude "marching armies" to independently verify every nook and cranny, therefore…

…we must how learn to deal with this reality.

Risk-based insight provides a novel approach to balance limited budgets and expectations for mission success

Risk-based insight provides the "Biggest Bang for the Buck"!